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### NEWS AND REVIEWS



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# EFFECTS OF IONIZING RADIATION ON WHITE POTATOES[1]

F. HEILIGMAN[2]

Among factors other than sprout inhibition which must be considered in the practical application of ionizing radiation as a process for increasing the shelf life of white potatoes are the effects of the treatment on (1) weight losses during storage, (2) the normal resistance of the tubers to decay, (3) peeling and trimming losses, and (4) cooking quality and acceptance. This report deals with an evaluation of some of these factors as observed in two varieties.

## EXPERIMENTAL

A limited quantity of Michigan-grown Sebago and Russet Rural potatoes was obtained from the Fission Products Laboratory, University of Michigan, Ann Arbor, Michigan. These were part of a large procurement used by the Fission Products Laboratory for detailed studies which will be reported at a later date.

The potatoes were harvested in October 1955, delivered to the radiation site on November first and held at 5°C. until irradiated at 0, 5, 10, 15, 20, 25, 50, 100 and 200 kilorep using a $cobalt^{60}$ source. On arrival at Quartermaster Food and Container Institute on January 3, 1956, there was no evidence of sprouting or decay in any of the lots; however, all lots showed signs of softening and had a slightly shriveled appearance. Triplicate samples of each treatment weighing approximately 2.0 kilograms, were packed on January 3, and stored at 13°C. and 22°C. (R.H. 85 to 90 per cent) After one and two-month storage periods, the various samples were examined for sprouting and storage losses. Certain treatments were evaluated for peel and trim losses and for differences in preference.

## RESULTS

### *Effects of Irradiation on Sprouting*

The extent of sprouting was determined by counting the number of sprouts over ¼ inch long in each sample and by weighing them after removal. Sprouting occurred normally in the untreated controls and was completely inhibited in all lots treated with 15 or more kilorep. The lots treated with 5 kilorep and stored at 13° C. had not sprouted after one month storage, but had developed many small (less than ¼ inch long) abnormal sprouts after two month's storage. Those stored at 22° C. had developed about 20 per cent as many sprouts as the untreated control after one month storage, and about 34 per cent as many sprouts after two month's storage. In the lots treated with 10 kilorep, only a rare sprout occurred in those stored at 22° C. and none was noted in the lots stored at 13° C. The weight loss through sprouting was negligible in all samples.

[1]Accepted for publication January 29, 1957.
This paper reports research undertaken at the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned Number 665 in a series of papers approved for publication. The views or conclusions contained in this report are those of the author. Therefore they are not to be construed as necessarily reflecting the views or endorsement of the Department of Defense.

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*Effects of Irradiation on Weight Loss and Decay*

Each sample, when withdrawn from storage, was again weighed. The gross loss in weight represented the combined losses caused by transpiration and respiration of the tubers, the growth and respiration of the contaminating microorganisms, and the growth and development of sprouts in the lots where sprouting occurred. All visible decay and sprouts were trimmed from each sample and each was weighed. The remainder was weighed and is expressed as the usable portion before peeling.

The findings (Figures 1 and 2) suggest that weight loss and decay in the samples treated with irradiation doses above that required to inhibit sprouting are greater than the weight loss and decay in the untreated controls. Doses at or near the minimum sprout inhibiting dose appear to cause a decrease in these losses.

*Effects of Irradiation on Peeling and Trim Losses and Preference Ratings*

After removing sprouts and visible decay, weighed portions of certain samples were studied to determine the effects of irradiation on peel and trim losses. For these studies, all peeling and trimming was done by hand using a potato peeler and paring knife. These results, shown in table 1, indicate that such losses were lowest in the lots treated in the minimum sprout inhibition range.

TABLE 1.—*Effects of irradiation on peeling and trimming losses in white potatoes during storage.*

| Dose (kr) | Initial | | | After One Month | | | After Two Months | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peel | Trim | Total | Peel | Trim | Total | Peel | Trim | Total |
| | | | | Sebago Variety Stored at 13° C. | | | | | |
| 0 | 10 | 3 | 13 | 29 | 3 | 32 | 16 | 4 | 20 |
| 10 | 18 | 2 | 20 | 18 | 8 | 26 | 17 | 7 | 24 |
| 20 | 19 | 5 | 24 | 16 | 19 | 35 | 20 | 15 | 35 |
| 100 | 11 | 3 | 14 | 17 | 9 | 26 | 12 | 5 | 17 |
| | | | | Russet Rural Variety Stored at 13° C. | | | | | |
| 0 | 18 | 3 | 21 | 16 | 5 | 21 | 17 | 6 | 23 |
| 5 | 20 | 2 | 22 | 17 | 3 | 20 | 19 | 3 | 22 |
| 10 | 18 | 0 | 18 | 19 | 3 | 22 | 24 | 5 | 29 |
| 20 | 33 | 5 | 38 | 18 | 8 | 26 | 20 | 14 | 34 |
| 100 | 13 | 5 | 18 | 17 | 25 | 42 | 25 | 11 | 36 |
| 200 | 16 | 18 | 34 | 17 | 19 | 36 | 30 | 16 | 46 |
| | | | | Sebago Variety Stored at 22° C. | | | | | |
| 0 | 22 | 3 | 25 | 20 | 3 | 23 | 17 | 15 | 32 |
| 10 | 13 | 3 | 16 | 17 | 13 | 30 | 16 | 6 | 22 |
| 20 | 25 | 7 | 32 | 18 | 17 | 35 | 12 | 10 | 22 |
| 100 | 14 | 3 | 17 | 19 | 19 | 38 | 19 | 11 | 30 |
| | | | | Russet Rural Variety Stored at 22° C. | | | | | |
| 0 | 32 | 3 | 35 | 22 | 3 | 25 | 26 | 6 | 32 |
| 5 | 13 | 2 | 15 | 15 | 3 | 18 | 11 | 11 | 22 |
| 10 | 18 | 3 | 21 | 22 | 4 | 26 | 17 | 9 | 26 |
| 20 | 14 | 5 | 19 | 20 | 20 | 40 | 18 | 20 | 38 |
| 100 | 22 | 10 | 32 | 18 | 22 | 40 | 7 | 51 | 58 |
| 200 | 15 | 20 | 35 | All Decay | | 100 | All Decay | | 100 |

Numbers represent per cent based on usable portion before peeling.

FIGURE I

EFFECTS OF IRRADIATION ON LOSSES IN SEBAGO WHITE POTATOES AFTER ONE MONTH STORAGE AT 22° C

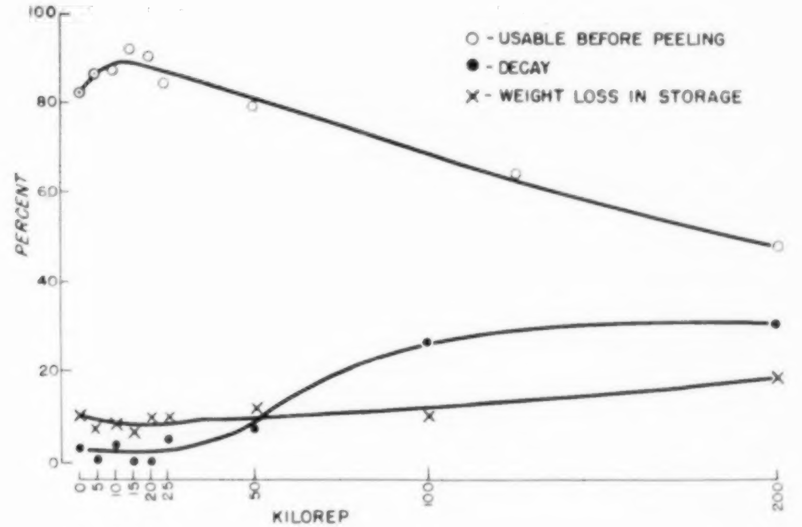
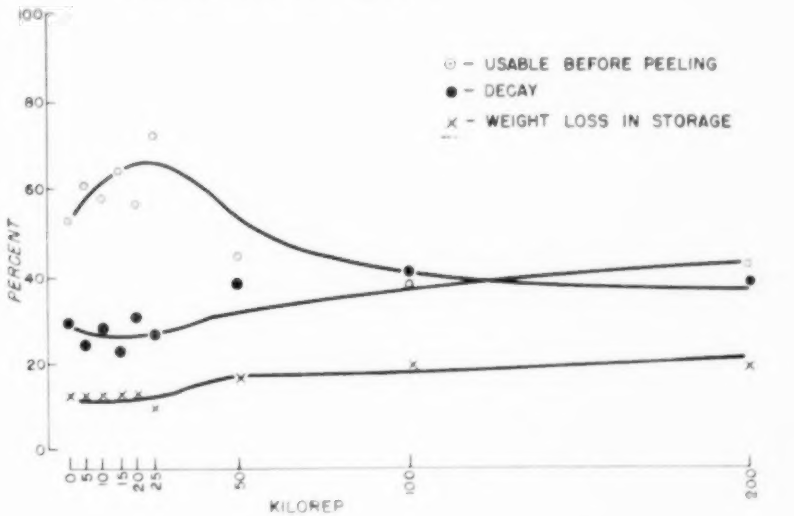



FIGURE II

EFFECTS OF IRRADIATION ON LOSSES IN SEBAGO WHITE POTATOES AFTER TWO MONTHS STORAGE AT 22° C



Diced samples, after cooking in boiling salted water, were drained and buttered. They were then rated for preference using the hedonic rating scale. These results, shown in table 2, clearly indicate that irradiation has no effect on preference.

TABLE 2.—*Effects of irradiation on flavor preference in white potatoes following gamma irradiation.*

Hedonic Mean for Main Effects

| Temperature | Temperature *vs.* Time — Time: Initial | One Month | Two Months | Average |
|---|---|---|---|---|
| 13°C | 6.7 | 6.7 | 6.7 | 6.7 |
| 22°C | 6.7 | 6.5 | 6.5 | 6.6 |
| Average | 6.7 | 6.6 | 6.6 | 6.6 |

| Time | Time *vs.* Irradiation Dose — Dose x $10^3$ rep.: 0 | 10 | 20 | 100 | Average |
|---|---|---|---|---|---|
| Initial | 6.9 | 6.8 | 6.8 | 6.4 | 6.7 |
| One Month | 6.8 | 6.8 | 6.4 | 6.6 | 6.7 |
| Two Months | 6.8 | 6.7 | 6.6 | 6.3 | 6.6 |
| Average | 6.8 | 6.8 | 6.6 | 6.5 | 6.7 |

| Temperature | Temperature *vs.* Variety: Sebago | Russet Rural | Average |
|---|---|---|---|
| 13°C | 6.6 | 6.8 | 6.7 |
| 22°C | 6.5 | 6.6 | 6.6 |
| Average | 6.6 | 6.7 | 6.6 |

## DISCUSSION AND CONCLUSIONS

This study confirms previous observations that 15 kilorep will completely inhibit sprouting and that, for practical purposes, 10 kilorep, or less, is ample. The study also confirms previous observations that doses up to 100 kilorep have little or no effect on preference.

It is interesting to note that weight loss, decay, and peel and trim loss appear to be lowest in the lots receiving irradiation in the minimum sprout inhibition range. Irradiation above this level appears to render the tubers more susceptible to decay and this change in susceptibility to decay increases with increasing dosage. In *in vitro* studies conducted by Waggoner (2), 30 and 80 kilorep affected wound periderm formation and did not increase the resistance of the tubers to decay. However, Sawyer, Dallyn, and Cotter (1) report that tubers treated with 12 kilorep would

not sprout and would develop wound periderm if held under optimum conditions. It does seem essential that dosages be kept at the minimum sprout inhibition level in order to keep losses to a minimum. Experiments now in progress are concerned with minimum practical dosage, the effects of this dosage on weight loss and decay, and the effect of pre- and post-irradiation environments on wound healings.

## Acknowledgments

The author wishes to express appreciation to Miss Jane A. Davidsaver and Miss Beverley J. Layman of the QMF&CI for their aid in conducting the peel and trim studies and preference testing.

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# FORMATION OF BUDS FROM CALLUS TISSUE IN THE POTATO[1]

F. I. LAUER AND F. A. KRANTZ[2]

The formation of callus tissue has received little attention in comparison to wound periderm formation. Jorgensen (2) in attempting graft chimaeras between tomato and potato found, in the cut surfaces of the graft union, low regenerative ability in potato compared with tomato tissue. Nobecourt (3) obtained callus proliferation on tuber slices placed on moist cotton or agar. Stewart and Caplin (4) and Chapman (1) obtained undifferentiated callus growth by culturing parenchyma tissue of tubers in a basic nutrient solution plus coconut milk and 2,4-D. Callus growth was obtained by Chapman on excised root tips.

This study concerns the formation of bud-producing callus tissue.

## FORMATION OF CALLUS ON TUBERS

Tubers of the Chisago variety with eyes removed were cut (1) lengthwise and (2) both lengthwise and crosswise and placed in moist sand at room temperature for five months. Formation of callus was confined to the cut surface in the area of stolon attachment of tubers cut lengthwise (Figure 1). Callus formations on a tuber cut both lengthwise and crosswise are shown in figure 2. On the lengthwise surfaces the calluses tend to be concentrated toward the surfaces facing the stolon end of the sections. On the crosswise surfaces, numerous calluses formed on the surfaces facing the stolon end (Figure 3). The surfaces facing the apex, as shown in figure 4, are free from callus. Wound periderm which formed immediately after wounding of tubers covered all cut surfaces. Callus developed between one and five months later.

## FORMATION OF BUD-PRODUCING CALLUS ON STEMS, ROOTS AND SEED PIECES OF PLANTS

Plants of the Chisago variety, started from a seed piece with a single eye, were grown in the greenhouse during winter and spring. After the plants had grown approximately three feet high, the entire stem and seed pieces were exposed to light. At this time all buds were removed from the plants and from some plants the seed pieces were also removed. Secondary buds were removed as they appeared.

*Stems*: Three to four weeks after bud removal callus formed on the surfaces of cuts which exposed the vascular system of the stems. Some of the stem calluses produced new buds that developed into shoots or tubers. A callus with numerous new buds and shoots located in the axil of a leaf is shown in figure 5. Figure 6 shows a callus with new buds and a developing tuber on the base of a stem from which the seed

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This investigation was supported in part from funds of the Graduate School, University of Minnesota, St. Paul, Minn. Paper number 3725 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.
[2] Research Fellow and Professor, respectively, Department of Horticulture, University of Minnesota, Institute of Agriculture, St. Paul 1, Minn.

FIGURE 1.—Callus formation in area of stolon attachment on the cut surface of a tuber cut lengthwise.

FIGURE 2.—Callus formations on the lengthwise surfaces of a tuber cut lengthwise and crosswise.

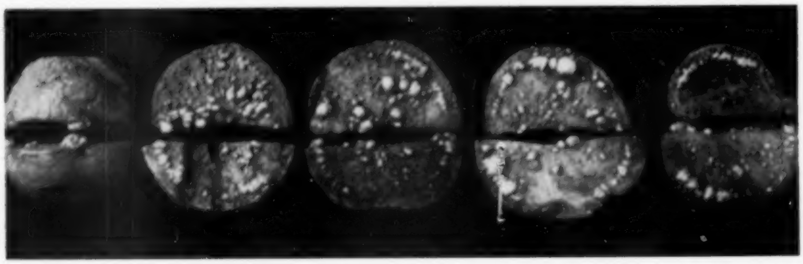

FIGURE 3.—Callus formations on the crosswise surfaces of tuber slices facing the stolon end of a tuber.

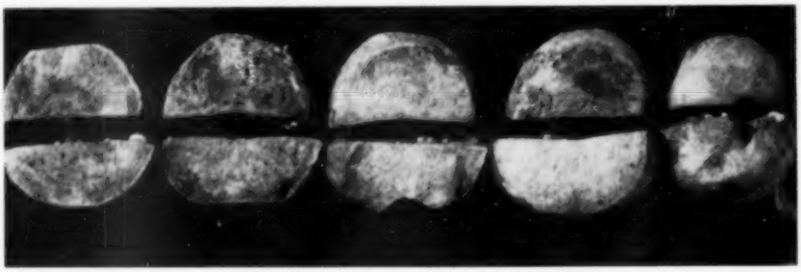

FIGURE 4.—The crosswise surfaces of tuber slices facing the apical end of a tuber.

FIGURE 5.—A callus with numerous new buds and shoots located in the axil of a leaf.

FIGURE 6.—A callus with new buds and a developing tuber on the base of a stem.

FIGURE 7.—Callus formations from the cut surfaces of stem incisions.

piece had been removed. The formation of callus tended to be restricted to the incision surface facing the base of the plant as shown in figure 7. The extent of the incision is shown on the stem at the extreme right. The callus on the stem at the extreme left produced new buds and stolons. With incisions made at right angles into the stems the callus invariably was restricted to the surface facing the base of the stem. The cut surface on the base of stems from which the seed piece had been removed produced the largest callus formations whereas the cut surface at the apex of stems did not produce any callus. Both large and small calluses, with and without new buds, were obtained.

*Roots*: On roots exposed to light, callus developed on uninjured surfaces three to four weeks after bud removal from the stems. The calluses were small and the volume of a single callus seldom exceeded one or two cubic millimeters. New buds which eventually produced tubers developed on some of these root calluses. Figure 8 shows the cells of an initiating callus on a root. Calluses, new buds and tubers from a root are shown in figure 9.

*Seed Pieces*: Calluses producing new buds that developed into tubers also formed on the cut surfaces of seed pieces. Callus formations with new buds on the cut surface of a seed piece are shown in figure 10.

*Number of Growing Points*: New buds arising on calluses were removed periodically. Of 709 new buds produced on calluses from forty plants, 337 developed on the surface of cuts resulting from the removal of seed pieces at the base of stems, 261 on roots, 94 on stems and 17 on seed pieces.

## Discussion

In the potato, callus develops primarily at the base or cut surfaces facing the base of stems and tubers. In contrast, Winkler (5) found that callus was readily formed on cut surfaces facing the stem apex in tomato and other *Solanum species*. Jorgensen (2), who used Winkler's (5)

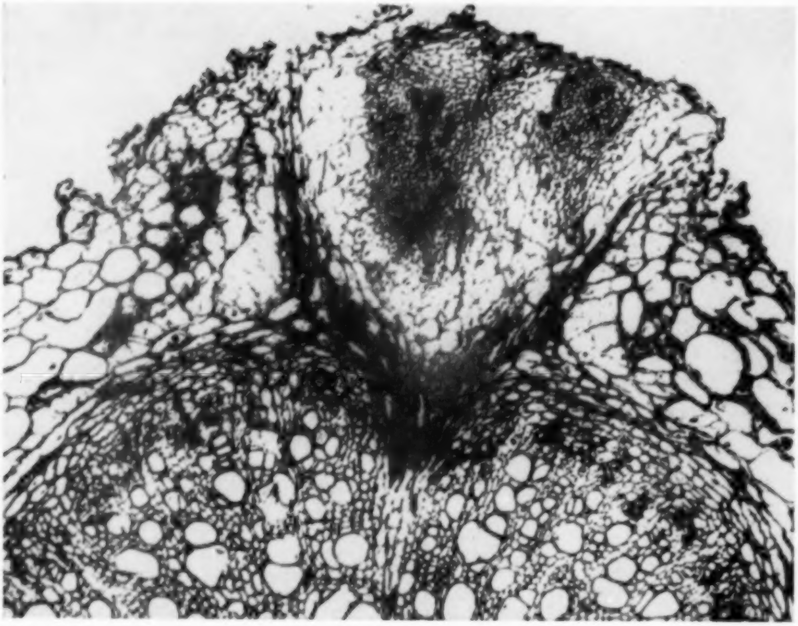

FIGURE 8.—A photo-micrograph of a cross section of a root with an initiating callus. —*Courtesy of E. T. Andersen, Institute of Agriculture, University of Minnesota.*

FIGURE 9.—New buds and stolons with tubers from callus formations of a root.

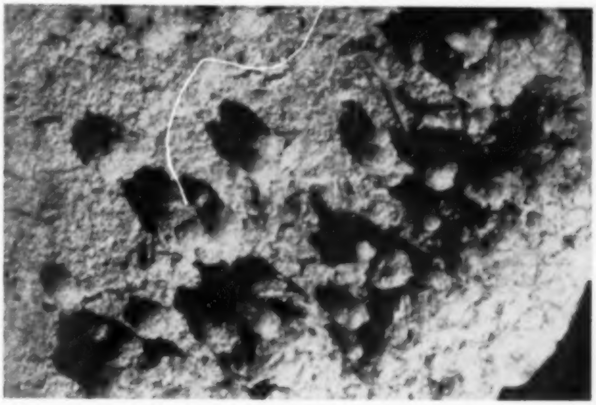

FIGURE 10.—New buds from callus formations on the cut surface of a seed piece.

grafting methods, probably based his observation of poor regenerative ability in the potato on cut surfaces facing the stem apex.

The differences apparent between wound periderm and callus formation suggest that the two tissues may be a result of different growth processes. First, the formation of callus is relatively slow compared with the formation of wound periderm. Second, it is probable that callus forms only in non-dormant tubers whereas wound periderm develops in both dormant and non-dormant tubers. Third, prior removal of a greater or lesser number of buds is necessary for callus formation. On the other hand, bud removal does not affect wound periderm formation. Fourth, the formation of callus entails an increase in cell number resulting, upon enlargement, in surface protuberances or calluses, hence, wound periderm, if a result of cell division, should tend to expand rather than depress the cut surface. Fifth, the difference in subsequent behavior of the two tissues should also be noted. Callus may continue to expand and eventually produce new buds but the surface of the wound periderm remains static. These considerations suggest the need for a reexamination of the theory that cell division plays an important role in wound periderm formation. There is no reason to assume that cell division is a necessity for wound periderm formation nor has it been demonstrated, to the best of our knowledge, that cells of the wound periderm undergo cell division. The differences between the growth processes of wound periderm and callus formation could be more easily explained on the assumption that wound periderm results from redifferentiation of existing cells.

## SUMMARY

Potato plants, with all organized buds removed, produced bud-forming callus on stems, roots and seed pieces. With the exception of roots, callus developed only on surfaces of cuts which exposed the vascular system. Formation of callus on stems and tubers tended to be restricted to cut surfaces facing the base. Differences in callus and wound periderm

formation are discussed and reinterpretation of wound periderm formation is suggested.

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# POTATO FUNGICIDE TESTS IN EASTERN VIRGINIA FOR THE EIGHT YEAR PERIOD 1949-1956[1]

R. S. Mullin[2]

As late blight will on occasion severely attack the spring Irish potato crop in Eastern Virginia, trials were started in 1949 to determine the relative effectiveness of some of the newer fungicides. Tests have been conducted each year since that time at Norfolk and from 1950 to 1954 on the Eastern Shore at Onley. Late blight however did not occur in greater than trace amounts during any of the eight years covered in these trials and as a result no real evaluation can be made on the fungicides used so far as their control of late blight is concerned. This is also true of other fungus foliage diseases. The experiment does indicate, however, that none of the fungicides or combinations of fungicides was toxic to the plants, nor was there any stimulation of plants and yields caused by any of the treatments.

Results of the various tests are listed below by years and location. In no case was any treatment significantly better than another or than the check. All yields given are of U. S. No. 1 potatoes.

### 1949
### Norfolk; Sebago Variety

Fungicides used for dust applications included 7 per cent Copper A, 7 per cent Tri-Basic Copper Sulphate, 7 per cent Tri-Basic Copper Sulphate plus 4 per cent sticker (Armour), 7 per cent Cop-O-Zink, 6 per cent Dithane Z-78, 13 per cent Zerlate and 7 per cent Robertson's Fungicide. Dusts were applied four times by means of a hand duster at the rate of 35-45 pounds per acre. Yields of treated plots varied from 161 bags (100 pounds) per acre for Robertson's Fungicide to 170 bags for Dithane. The check yielded 150 bags per acre.

[1]Accepted for publication February 11, 1957.
[2]Plant Pathologist, Virginia Truck Experiment Station, Norfolk, Va.

### 1950
### Norfolk; Sebago Variety

The fungicides used at Norfolk in 1950 were 7 per cent Tri-Basic Copper Sulphate, 7 per cent Tri-Basic Copper Sulphate plus 4 per cent sticker (Armour), 8 per cent Dithane Z-78, 8 per cent Dithane Z-78 plus 4 per cent sticker, 7 per cent Cop-O-Zink, 12 per cent Zerlate, 7 per cent Robertson's Fungicide, 7 per cent Crag 658 and 4 per cent Orthocide 406. Dusts were applied four times by means of a hand duster at the rate of 35-45 pounds per acre. Yields for treated plots ranged from 244 bags per acre for Dithane Z-78 plus sticker to 290 for Zerlate. The yield from the check plots was 284 bags per acre.

### 1950
### Onley; Cobbler Variety

Except for the omission of Zerlate and Orthocide 406, the same fungicides used at Norfolk in 1950 were also used at Onley. Five dust applications were made with a hand duster at 35-45 pounds per acre. Yields varied from 187 bags per acre where Dithane Z-78 plus sticker was applied to 207 where Crag 658 was used. The check gave the highest yield with 220 bags per acre.

### 1951
### Norfolk; Sebago Variety

Microgel at 7 per cent, 7 per cent Cop-O-Zink, 5 per cent Cuprocide, 7 per cent Robertson's Fungicide, 7 per cent C-O-C-S, 8 per cent Crag 658, 8 per cent Orthocide 406, 5 per cent Vancide-51, 8 per cent Manzate, and 8 per cent Dithane Z-78 were applied four times with a hand duster at 35-45 pounds per acre. The lowest yield of 245 bags per acre occurred on plots treated with Robertson's Fungicide and the highest yield of 280 bags per acre on Dithane Z-78 treated plots. The check yielded 279 bags per acre.

### 1951
### Onley; Cobbler Variety

With the exception of Vancide-51 the same fungicides used at Norfolk were also used at Onley in 1951. Number and method of dust applications was the same. The lowest yield occurred on C-O-C-S treated plots, this being 188 bags per acre, and the highest, 226 bags, on plots treated with Orthocide 406. The check yield was 208 bags per acre.

### 1952
### Norfolk; Sebago Variety

In 1952 four dust applications were made at the rate of 35-45 pounds per application. Fungicides used were 7 per cent Cop-O-Zink, 7 per cent Copper-Manganese, 8 per cent Dithane Z-78, and 8 per cent Manzate. This year sprays were also used at Norfolk, three spray applications of 125-150 gallons per acre being made with a Bean Spartan power sprayer.

Fungicides used and active ingredients per 100 gallons of water were Copper-Manganese, 2 pounds; Dithane Z-78, 1 pound; Manzate, 1 pound; and Dithane D-14, ¾ pint plus manganese sulphate, 1 pound. The highest yield for dust treated plots was 222 bags per acre with Dithane Z-78 and the lowest 205 bags with Cop-O-Zink. The highest yield from the spray plots was 226 bags from plots receiving Dithane Z-78 and the lowest 218 bags from plots sprayed with Dithane D-14 plus manganese sulphate. The check produced the highest yield of all plots yielding 234 bags per acre.

### 1952
### Onley; Cobbler Variety

In addition to the four materials used in the dust treatments at Norfolk, 7 per cent C-O-C-S, 7 per cent Calumet Copper, 8 per cent Orthocide 406, 8 per cent Crag 658, and 7 per cent Robertson's Fungicide were also used at Onley. Four treatments were applied with a hand duster at 35-45 pounds per acre. The highest yield, 192 bags per acre, was obtained with Cop-O-Zink whereas C-O-C-S gave the lowest yield of 174 bags. The check yielded 185 bags per acre.

### 1953
### Norfolk; Sebago Variety

Both dusts and sprays were used in a single test at Norfolk in 1953. Dust treatments, applied four times with a power duster at 35-45 pounds per acre, included 7 per cent Cop-O-Zink, 8 per cent Dithane Z-78, 8 per cent Manzate, 8 per cent Crag 658 and a no fungicide check on which talc was applied. This talc was the same as was used as a diluent for all fungicides. Three spray applications were made with a small power sprayer at 100-125 gallons per acre. Materials and rates of active ingredients per 100 gallons used were Cop-O-Zink, 2 pounds; Dithane Z-78, 1 pound; Manzate, 1 pound; and Tri-Basic Copper Sulphate 2 pounds plus Dithane Z-78, 1 pound.

Among the dust treatments Cop-O-Zink and Crag 658 gave the highest yields of 88 bags per acre. The lowest yielding fungicide treatment was Dithane Z-78 with 78 bags and the talc treated check yielded 72 bags per acre.

Cop-O-Zink spray treatment gave the highest yield of 112 bags per acre whereas Dithane Z-78 was lowest with 93. The non-treated check for the entire experiment yielded 100 bags per acre.

### 1953
### Onley; Cobbler Variety

In addition to the fungicides used as dust treatments at Norfolk, 7 per cent Tri-Basic Copper Sulphate, 7 per cent C-O-C-S, 7 per cent Robertson's Fungicide, 7 per cent Calumet Copper and 8 per cent Orthocide 50-W (same as Orthocide 406) were used at Onley. Four applications at 35-45 pounds per acre were made with a hand duster. The highest yield, 239 bags per acre, was from Calumet Copper treated plots, whereas the lowest fungicide treatment was 215 on Cop-O-Zinc plots. The talc treated check yielded 202 bags per acre.

### 1954
### Norfolk; Sebago Variety

Only spray treatments were used at Norfolk in 1954. Treatments were applied four times with a compressed air hand sprayer. Materials used and active ingredient per 100 gallons of water were Copper-Manganese, 2 pounds; Orthocide 50-W, 1½ pound; Crag 658, 1 pound; Cop-O-Zink, 2 pounds; Robertson's Fungicide, 2 pounds; Dithane Z-78, 1 pound; and Tri-Basic Copper Sulphate, 1 pound, plus Dithane Z-78, one half pound. The highest yield was 144 bags per acre from Copper-Manganese treated plots and the lowest on treated plots was 127 bags from plots receiving Dithane Z-78. The check plot yield was 117 bags per acre.

### 1954
### Onley; Cobbler Variety

Fungicides used as dusts at Onley included 7 per cent Copper-Manganese, 8 per cent Orthocide 50-W, 8 per cent Crag 658, 7 per cent Cop-O-Zink, 7 per cent Robertson's Fungicide, 8 per cent Dithane Z-78, 8 per cent Manzate, 7 per cent C-O-C-S, and 4 per cent Copper Sulphate plus 4 per cent Dithane Z-78. Four treatments of 35-45 pounds per acre were applied with a hand duster. Yields varied from a low of 50 bags per acre from Copper-Manganese plots to a high of 69 bags for plots receiving Robertson's Fungicide and for the check. Very dry weather seriously cut production at Onley for 1954.

### 1955
### Norfolk; Sebago Variety

In 1955 fungicides used as sprays and active ingredients per 100 gallons were Copper-Manganese, 2 pounds; Orthocide 50-W, 1½ pounds; Crag 658, 1 pound; Cop-O-Zink, 2 pounds; Tri-Basic Copper Sulphate, 2 pounds; Dithane Z-78, 1 pound; C-O-C-S, 2 pounds; Manzate, 1 pound; and Tennam, 1¾ pounds. Three applications of 100-125 gallons per acre were made with a compressed air hand sprayer. The highest yield, 118 bags per acre, was on Manzate treated plots, and the lowest of the fungicide treatments was 87 bags from Orthocide 50-W plots. The check yield was 85 bags per acre.

### 1956
### Norfolk; Sebago Variety

Fungicides and pounds active ingredient used in 1956 were Vancide Z-65, 1⅓ pound; Vancide M, 1⅓ pound; Tennam, 1¾ pound; Orthocide 50-W. 1½ pound; Dithane Z-78, 1⅓ pound; Copper-Manganese, 2 pounds; Cyanamid 8599, ½ pound; Cyanamid 14307, ½ pound; Manzate, 1 pound; C-O-C-S, 2 pounds; Vancide Z-65, 1⅓ pound, plus C-O-C-S, 2 pounds; and Vancide M, 1⅓ pound, plus C-O-C-S, 2 pounds. Four sprays of 100-125 gallons per acre were applied with a compressed air hand sprayer. Orthocide 50-W and Tennam treated plots gave the highest yields with 139 and 138 bags per acre respectively. Cyanamid 8599 plots yielded least with 104 bags while the check yield was 110 bags per acre.

## Conclusions

During the eight years covered by this experiment no statistically significant yield increases were obtained over the non-treated checks by any of the dusts or sprays applied at Norfolk and Onley. Although late blight was occasionally present in trace amounts, in no case did it cause appreciable defoliation or reduction in yield, even on untreated plots.

While lack of diseases prevented comparison of fungicides on a disease control basis, it did permit comparison as to toxicity to, or stimulation of, plants. In no case was any fungicide noted to cause any toxic conditions to occur on plants, nor was there indication of any stimulation either in top growth or in yields.

It is considered that in the average year it is unnecessary for a grower to dust or spray potatoes with a fungicide in the Norfolk and Eastern Shore of Virginia area. However in cold, damp springs late blight is likely to occur and a fungicide should be applied. When such conditions are prevalent a recommendation for dusting or spraying is made in the Late Blight Forecast issued by the Virginia Truck Experiment Station.

# FIELD RESISTANCE OF THE POTATO SELECTION ND 457-1 TO VIRUS Y[1,2]

ROBERT H. JOHANSEN[3]

## INTRODUCTION

Potato virus Y is present in most all potato growing areas of the world and causes considerable losses in some sections to both table stock and certified seed growers. Dykstra (6) reported that severe mosaic caused by virus Y alone, or in a combination with virus A or X, reduced the yield 75 to 90 per cent. Schultz *et. al.* (10) have shown that virus Y was capable of causing more than 50 per cent reduction in yield. In the field virus Y may be transmitted mechanically (10) but it is more commonly transmitted by insects, particularly the green peach aphid, *Myzus persicae* (3, 7, 9).

In most potato varieties (1) virus Y causes leaf drop, veinbanding and stem necrotic streak in the first year of infection and a severe mosaic in the second and subsequent years. The symptoms of rugose mosaic, caused by the combination of virus X and Y (5, 8) are chlorosis and diffused mottling, distinct dwarfing, leaf dropping, brittleness, rugosity, premature death of the plant and considerable reduction in yield. Darby *et al.* (5) studied 25 isolates of potato virus Y from various parts of the United States, England and New Zealand. The results of their investigation emphasized the difficulties encountered in attempting to diagnose causative potato viruses from symptoms alone, as isolates or strains of virus Y produced varied types of symptoms on the same and different potato varieties.

The nature of virus Y resistance found in potato hybrids is not clearly known. Smith (11) reported that resistance to virus infection exhibited by certain plants was often more apparent than real, and may consist merely in the fact that for some reason, possibly purely mechanical, the plant is avoided by the insect vector and so escapes infection. Corbett (4) demonstrated hypersensitive resistance to virus Y by adding indoleacetic acid in lanolin near the leaf base, which in turn retarded leaf abscission from 6 to 14 days and thus allowed the plant to become systemically infected. Hutton (8) has indicated that inactivating enzymes may be present, inducing virus Y resistance. At the present, immunity from this virus in the common potato has not been achieved. However, some varieties have been developed that possess field resistance to the virus (4). Bawden and Kassanis (2) reported that the American variety Katahdin showed the highest degree of field resistance among the varieties tested. According to Stevenson (12) a weak resistance to virus Y exists in Chippewa and Katahdin; but higher degrees of resistance are to be found in several numbered varieties. Timian (13) found field resistance to virus Y in the North Dakota selection ND 457-1.

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[2]Taken from part of a thesis for the degree of Master of Science. Acknowledgments are extended to the late Dr. J. H. Schultz for suggestions and criticisms during the initial course of this study and to Dr. Wm. G. Hoyman for his assistance during the final phase of the investigation.

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ND 457-1 was grown in the field for the first time in 1945 and on several subsequent occasions it was planted in fields where the current season infection of virus Y was abundant in other selections and varieties but in only a few instances were virus Y symptoms observed on ND 457-1. The purpose of the present study was to determine the degree of field resistance to virus Y possessed by ND 457-1, and to determine the incidence of virus Y in tubers harvested from infected plants.

## Materials and Methods

The degree of field resistance to virus Y possessed by ND 457-1 was compared with that of the susceptible variety Red Pontiac. Both varieties were grown in each of 2 plots consisting of 6 replications designed as a randomized block. Each replicate consisted of four 25-hill rows with appropriate guard plants. Plots were designated as 1 and 2. The plots were approximately ¾ of a mile apart and differed in the fact that the west side of plot 1 was located adjacent to a planting of Nanking cherry (*Prunus tomentosa*), whereas plot 2 was located in a field approximately ½ mile away from any trees or shrubs.

Selection ND 530,[4] a virus Y carrier, was planted as a source of field inoculum and represented 4 and 8 per cent of the plants in plots 1 and 2, respectively. In both plots ND 530 was planted in the 2nd and 3rd rows of each replication. In plot 1 it was planted as the 9th and 18th hills and as the 6th, 11th, 16th and 21st hills in plot 2. The Red Pontiac and ND 457-1 seed was free from virus Y. The plots were planted May 21 and 22, 1955. Although no specific aphicides were applied to the plants it was necessary to dust the potatoes early in the season with DDT and toxaphene to control the Colorado potato beetle, potato leaf hopper and the potato flea beetle. Aphid counts and identifications were not recorded but observations were made to their relative abundance in each plot.

On July 15, and during each subsequent weekly interval until August 12, the exact location of each plant showing symptoms was recorded. Because of drought, and injury caused by an infestation of leaf hoppers, it was impossible to distinguish virus Y symptoms after the 12th of August. Plants that expressed symptoms of leaf drop, vein-banding and necrotic spots were recorded as infected. At harvest the largest tuber from each hill of Red Pontiac and ND 457-1 was saved. In plot 1 additional samples representing all the tubers from 22 hills of infected Red Pontiac and 13 hills of infected ND 457-1 were saved separately. All tubers saved at harvest were grown in the greenhouse, with each tuber identified as to the original location of the plant grown in the field.

Ten random plants of Red Pontiac and ND 457-1, both with and without field symptoms, taken from each of 5 replications in plot 1, were tested in the greenhouse on indicator plants for the presence of virus X and virus Y. The test for virus X was conducted because some strains of virus X cause symptoms similar to those of virus Y. The test for virus Y was conducted to prove that some plants, particularly of ND 457-1, were not symptomless carriers. *Gomphrena globosa* and *Nicotiana glutinosa* were used as indicators for the viruses X and Y, respectively.

[4]Tests conducted by Dr. W. G. Hoyman indicated that ND 530 was infected with a virulent strain of virus Y.

## Results and Discussion

Symptoms of virus Y were first observed and recorded in plot 1 on July 15. Subsequent observations and records were made July 22, 29 and August 5 and 12. These symptoms consisted of mottling, vein-banding, necrotic spot, leaf drop and stem necrotic streak. Tables 1 and 2 reveal the dates that symptoms were observed and the number of plants that showed current season infection. A total of 58.2 per cent of the Red Pontiac plants and only 3.38 per cent of the ND 457-1 plants revealed symptoms.

Table 1.—*Dates when current season virus Y symptoms were observed and the number of Red Pontiac showing symptoms in plot 1.*

| Replication | Number of Plants | Number with No Symptoms | Number with Symptoms | | | | | Total with Symptoms |
|---|---|---|---|---|---|---|---|---|
| | | | July | | | August | | |
| | | | 15 | 22 | 29 | 5 | 12 | |
| A | 92 | 30 | 9 | 23 | 28 | 2 | 0 | 62 |
| B | 91 | 45 | 12 | 13 | 21 | 0 | 0 | 46 |
| C | 88 | 35 | 6 | 0 | 38 | 9 | 0 | 53 |
| D | 78 | 35 | 6 | 17 | 18 | 2 | 0 | 43 |
| E | 92 | 35 | 10 | 28 | 18 | 1 | 0 | 57 |
| F | 90 | 42 | 8 | 19 | 15 | 6 | 0 | 48 |
| Total Plants | 531 | 222 | 51 | 100 | 138 | 20 | 0 | 309 |
| Total per cent virus Y | | | 9.6 | 28.4 | 54.4 | 58.2 | 58.2 | |

Table 2.—*Dates when current season virus Y symptoms were observed and the number of ND 457-1 showing symptoms in plot 1.*

| Replications | Number of Plants | Number with No Symptoms | Number with Symptoms | | | | | Total with Symptoms |
|---|---|---|---|---|---|---|---|---|
| | | | July | | | August | | |
| | | | 15 | 22 | 29 | 5 | 12 | |
| A | 95 | 94 | 0 | 0 | 0 | 1 | 0 | 1 |
| B | 91 | 88 | 0 | 0 | 3 | 0 | 0 | 3 |
| C | 95 | 93 | 0 | 1 | 1 | 0 | 0 | 2 |
| D | 93 | 86 | 1 | 2 | 3 | 0 | 1 | 7 |
| E | 96 | 90 | 0 | 1 | 3 | 1 | 1 | 6 |
| F | 92 | 92 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Plants | 562 | 543 | 1 | 4 | 10 | 2 | 2 | 19 |
| Total per cent virus Y | | | .18 | .89 | 2.66 | 3.02 | 3.38 | |

In plot 2 symptoms on Red Pontiac were not observed until August 5, even though the same periodical checks were made in this plot as in plot 1. The dates at which symptoms were observed and the number

of plants that showed current season infection are shown in table 3. A total of 5.8 per cent of the Red Pontiac was infected. No symptoms were found on ND 457-1 in plot 2.

It was apparent that the location of the plots was an important factor in the spread of virus Y. The pattern of infection indicated that aphids may have been harbored by the Nanking cherries adjacent to the west side of plot 1. Aphids were observed as being prevalent during July and August in plot 1 and during August in plot 2. Although aphid counts were not recorded at any time a larger infestation was observed in plot 1. Plot 2, located approximately ½ mile away from any trees or shrubs, evidently did not have the environmental conditions conducive for aphid infestation.

There was little indication that virus Y was spread by mechanical contact, as it was common to have a non-infected plant located between two infected plants or non-infected plants on either side of ND 530. The close proximity of infection occurring near ND 530 indicated that the source of inoculum was an important factor in the spread of virus Y.

Virus Y symptoms occurring on plants that were indexed in the greenhouse indicated that not all infected plants were recorded in the field. This variance may have been due to a late infestation of aphids and/or the fact that it was difficult to determine late season virus Y symptoms due to injury caused by potato leafhoppers. The results comparing the field and greenhouse tests are shown in table 4.

When Red Pontiac tubers from plants recorded as infected in the field were planted in the greenhouse, the plants showed chlorosis, diffused mottling, rugosity, leaf dropping, brittleness and premature death. Symptoms found on the greenhouse-grown ND 457-1 were veinbanding, chlorosis, necrotic spot, leaf dropping and brittleness.

Plants grown in the greenhouse indicated there was little or no correlation between current season infection of virus Y and the size of individual tubers within infected hills. Nearly all the tubers from each hill of infected Red Pontiac produced plants with symptoms of virus Y. Two hills (Table 5) represented by 1 and 2 tubers, respectively, produced plants with no symptoms. The fact that nearly all the Red Pontiac tubers contained virus Y indicated the virus moved quite rapidly within the plants to the tubers. Tubers grown from separate hills of ND 457-1, as shown in table 6, having current season symptoms of virus Y produced plants with and without symptoms. It was generally the smaller tubers that produced plants with symptoms. This may be explained on the basis of a lower level of virus concentration and/or slower translocation of the virus in infected ND 457-1 plants, whereby the virus moved only into the smaller tubers located at a higher position on the plant stem. The dates at which the first field symptoms were recorded did not seem to be a factor since as many early as late recorded plants produced greenhouse plants with symptoms of virus Y. Since the last recording date of all tubers from individual hills harvested in tables 5 and 6 was July 29, it is possible that the dates field symptoms were recorded were not of too much significance. It is probable that if symptoms had been recorded later in the season, a larger percentage of the tubers from infected ND 457-1 plants would have been free from virus Y.

TABLE 3.—*Dates when current season virus Y symptoms were observed and the number of Red Pontiac showing symptoms in plot 2.*

| Replications | Number of Plants | Number with No Symptoms | Number with Symptoms | | | | | Total with Symptoms |
|---|---|---|---|---|---|---|---|---|
| | | | July | | | August | | |
| | | | 15 | 22 | 29 | 5 | 12 | |
| A | 84 | 81 | 0 | 0 | 0 | 1 | 2 | 3 |
| B | 82 | 76 | 0 | 0 | 0 | 3 | 3 | 6 |
| C | 93 | 82 | 0 | 0 | 0 | 11 | 0 | 11 |
| D | 66 | 63 | 0 | 0 | 0 | 0 | 3 | 3 |
| E | 80 | 75 | 0 | 0 | 0 | 0 | 5 | 5 |
| F | 75 | 75 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Plants | 480 | 452 | 0 | 0 | 0 | 15 | 13 | 28 |
| Total per cent virus Y | | | 0 | 0 | 0 | 3.1 | 5.8 | |

TABLE 4.—*Comparison of the percentage of field and greenhouse plants showing symptoms of virus Y.*

| | Field | Greenhouse |
|---|---|---|
| | Per cent Infected | Per cent Infected |
| Plot 1 | | |
| Red Pontiac | 58.20 | 67.50 |
| ND 457-1 | 3.38 | 3.47 |
| Plot 2 | | |
| Red Pontiac | 5.83 | 9.27 |
| ND 457-1 | 0.0 | 0.0 |

Following plant emergence in the greenhouse, symptoms appeared very rapidly on Red Pontiac and slowly on most ND 457-1. In some cases virus Y symptoms did not show on ND 457-1 until 45 days after emergence. It was evident that some factor or factors possessed by ND 457-1 caused a delay in the appearance of virus Y symptoms in the greenhouse. After virus Y symptoms appeared on ND 457-1, most of the plants showed complete necrosis at the end of 60 days. The ultimate death of infected plants would be an advantage in maintaining fields of ND 457-1 free of virus Y.

Fifty greenhouse plants of Red Pontiac and the same number of ND 457-1, grown from tubers from plot 1, were selected at random and indexed for the presence of viruses X and Y by the use of indicator plants. Some of the plants selected expressed visual symptoms of virus Y whereas others did not. No symptoms were recorded on *G. globosa*, a local lesion indicator for all strains of virus X, so it can be assumed that both varieties may have been free from virus X. *N. glutinosa* was

TABLE 5.—*Plot 1. Number of Red Pontiac plants showing virus Y symptoms when infected hill units were indexed in the greenhouse.*

| Replication | Row | Plant | Dates Virus Y Symptoms Observed in Field | Total Number of Plants Grown from Each Hill | Number with Symptoms | Number without Symptoms |
|---|---|---|---|---|---|---|
| A | 3 | 7 | 7/15 | 3 | 3 | 0 |
| A | 5 | 10 | 7/15 | 1 | 1 | 0 |
| B | 3 | 8 | 7/15 | 2 | 2 | 0 |
| B | 4 | 11 | 7/15 | 1 | 1 | 0 |
| C | 2 | 10 | 7/15 | 5 | 5 | 0 |
| D | 3 | 10 | 7/15 | 2 | 2 | 0 |
| D | 3 | 16 | 7/15 | 5 | 5 | 0 |
| D | 3 | 15 | 7/15 | 7 | 7 | 0 |
| E | 4 | 20 | 7/15 | 1 | 1 | 0 |
| E | 3 | 10 | 7/15 | 7 | 7 | 0 |
| A | 4 | 5 | 7/22 | 2 | 2 | 0 |
| A | 3 | 6 | 7/22 | 2 | 2 | 0 |
| B | 3 | 12 | 7/22 | 7 | 7 | 0 |
| B | 5 | 12 | 7/22 | 3 | 3 | 0 |
| D | 2 | 6 | 7/22 | 2 | 0 | 2 |
| E | 3 | 6 | 7/22 | 1 | 0 | 1 |
| D | 2 | 7 | 7/22 | 2 | 2 | 0 |
| E | 4 | 8 | 7/22 | 4 | 4 | 0 |
| E | 4 | 14 | 7/22 | 3 | 3 | 0 |
| E | 4 | 6 | 7/22 | 3 | 3 | 0 |
| C | 2 | 2 | 7/29 | 3 | 3 | 0 |
| C | 4 | 5 | 7/29 | 1 | 1 | 0 |
| Total | | | | 67 | 64 | 3 |

TABLE 6.—*Plot 1. Number of ND 457-1 plants showing virus Y symptoms when infected hill units were indexed in the greenhouse.*

| Replication | Row | Plant | Dates Virus Y Symptoms Observed in Field | Total Number of Plants Grown from Each Hill | Number with Symptoms | Number without Symptoms |
|---|---|---|---|---|---|---|
| D | 3 | 8 | 7/15 | 3 | 2 | 1 |
| A | 3 | 8 | 7/22 | 3 | 3 | 0 |
| C | 3 | 10 | 7/22 | 8 | 0 | 8 |
| D | 4 | 11 | 7/22 | 3 | 0 | 3 |
| E | 2 | 15 | 7/22 | 5 | 2 | 3 |
| B | 4 | 19 | 7/29 | 2 | 2 | 0 |
| B | 3 | 8 | 7/29 | 4 | 4 | 0 |
| C | 4 | 23 | 7/29 | 5 | 0 | 5 |
| D | 5 | 16 | 7/29 | 4 | 0 | 4 |
| D | 2 | 11 | 7/29 | 1 | 0 | 1 |
| E | 4 | 20 | 7/29 | 5 | 4 | 1 |
| E | 4 | 17 | 7/29 | 5 | 3 | 2 |
| E | 2 | 15 | 7/29 | 3 | 0 | 3 |
| Total | | | | 51 | 20 | 31 |

chosen as an indicator for the ND 530 strain of virus Y. Since the test on *G. globosa* showed that virus X was not present, it was assumed that the mottling and necrosis on *N. glutinosa* was caused by virus Y. All plants of Red Pontiac and ND 457-1 which expressed visible symptoms of virus Y gave a positive reaction on *N. glutinosa*. The fact that symptomless plants caused no reaction on *N. glutinosa* indicated they were not symptomless carriers of virus Y.

## Summary and Conclusions

The degree of field resistance to virus Y possessed by ND 457-1 was compared with that of the susceptible variety Red Pontiac. Both varieties were grown in each of 2 plots designated as plots 1 and 2. The plots differed in the fact that the west side of plot 1 was located adjacent to a planting of Nanking cherry (*Prunus tomentosa*) whereas plot 2 was located in a field approximately ½ mile away from any trees or shrubs. The selection ND 530, infected with a virulent strain of virus Y, was used as the source of inoculum in plots 1 and 2 for field transmission of the virus by aphids.

Symptoms of virus Y recorded at 5 weekly intervals revealed that 58.2 per cent of the Red Pontiac and only 3.38 per cent of the ND 457-1 in plot 1 expressed symptoms. Similar recordings showed 5.58 per cent of the Red Pontiac and none of the ND 457-1 in plot 2 expressed symptoms of virus Y. It is possible the environmental conditions conducive for aphid infestation did not exist in the vicinity of plot 2. Such conditions are comparable to those occurring throughout North Dakota where most North Dakota potatoes are grown.

Tubers harvested from plots 1 and 2 were planted in the greenhouse in order to: (1) establish a more positive identity of virus Y; (2) to determine if additional plants would express symptoms; and (3) to determine if tuber size within each infected hill was of any consequence. Greenhouse results revealed that not all infected plants were recorded in the field. However, a similar rate of infection existed for each variety. The greenhouse test to determine if any relation existed between current season infection of virus Y and the size of individual tubers within infected hills, showed little or no correlation. Nearly all the tubers from each hill of infected Red Pontiac produced plants with symptoms of virus Y. Tubers grown from hill units of ND 457-1, recorded as current season symptoms of virus Y in the field produced plants with and without virus Y symptoms. It was generally the smaller tubers that produced plants with symptoms. Symptoms appearing on some ND 457-1 plants in the greenhouse were very erratic in that some did not appear until 45 days following emergence. After the infected ND 457-1 plants expressing symptoms were grown in the greenhouse for 60 days, most of them showed complete necrosis.

When tested on *G. globosa* both varieties expressed a negative reaction to virus X regardless of whether the plants did or did not show virus symptoms. All plants showing visual symptoms of virus Y expressed a positive reaction when tested on *N. glutinosa;* this test also indicated that plants from both varieties expressing no symptoms were not symptomless carriers of virus Y.

Data representing exposure to natural infection revealed that in comparison to the susceptible variety Red Pontiac, ND 457-1 possessed a high degree of field resistance to the virulent strain of virus Y carried by ND 530.

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# INFLUENCE OF GAMMA IRRADIATION OF POTATO TUBERS ON THE RATE OF RESPIRATION[1]

F. G. GUSTAFSON, L. E. BROWNELL, AND R. A. MARTENS[2]

Respiration is one of the fundamental processes of all living organisms. Therefore, it was included as one of the processes to be investigated in the study of the influence of gamma irradiation on the sprout inhibition of potatoes. Sussman (4) has previously reported the results of short-time experiments with gamma-irradiated potatoes.

## MATERIAL AND METHODS

Two varieties of potatoes were used, the Sebago and the Pontiac. The former variety was obtained from Michigan State University in November, 1955 and the latter from Homestead, Florida,* about the middle of March, 1956. Both varieties were stored at 45° F. during the course of the experiment.

The irradiation was performed in the radiation cave of the Fission Products Laboratory at the University of Michigan. The potatoes, in paper bags, were placed in the center well, *i.e.*, within the circle of cobalt rods, and irradiated for various periods of time to give the desired dosages. The tubers, still in the bags, were returned to the storage room and removed as needed. Before treatment, the tubers had been carefully selected for uniformity. Dosages of 0, 5, 15, 25, 50, 100, and 200 kilorep were used. Both carbon dioxide and oxygen consumption were measured, but in different experiments and on different tubers.

*Carbon Dioxide Production.*—The $CO_2$ was determined by the Pettenkofer method (Figure 1). Carbon dioxide free air was drawn through the large glass jars containing the tubers and then through the long Pettenkofer tubes where the $CO_2$ was absorbed by the $Ba(OH)_2$. Determining the titer of the $Ba(OH)_2$ before and after the passage of the $CO_2$ enables one to calculate the amount of $CO_2$ produced by the tubers over a given period. Several hours previous to the $CO_2$ determination the tubers were removed from the storage room and placed in large jars in the constant temperature chamber at the same temperature as the storage room. For two hours air was drawn through the apparatus to establish equilibrium and then two collections, each lasting for three hours, were made. The respiration has been expressed as $CO_2$ per kilogram fresh potato tubers. The same tubers were used throughout the experiment.

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This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces and has been assigned No. 672 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or endorsement of the Department of Defense.

[2] Professor of Botany, Supervisor of Fission Products Laboratory, and Research Assistant, respectively, Engineering Research Institute, University of Michigan, Ann Arbor, Mich.

*We are indebted to Dr. John C. Noonan for these potatoes.

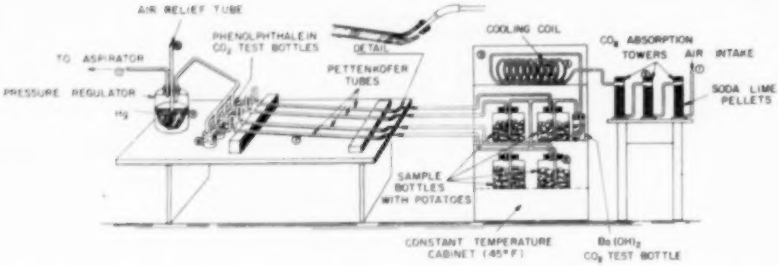


FIGURE 1.—Schematic view of gas train used in whole-tuber respiration studies.

*Oxygen Consumption.*—The oxygen consumption was determined by the manometric technique in the usual manner. Respiration vessels of approximately 90 mls. were used instead of the usual 25-ml vessels, to facilitate the use of a larger amount of plant material. All the determinations were made at 28° C (82° F) because no facilities were available to use the storage temperature of 45° F.

For an experiment three tubers from each lot to be studied were used. Sections 0.8 mm. thick and 12 mm. in diameter were cut with a microtome from cylinders cut around an "eye." Two such cylinders were cut from each tuber, midway between the stem end and the apex. Seven disks were cut from each cylinder in sequence, the first one containing the surface. Each assay (determination) was made in duplicate and 21 disks were used for each assay. In all experiments the disks were used as soon as cut. During the assay they were immersed in 0.01 M phosphate buffer of pH 6.0. A period of 50 minutes was allowed for equilibration to be reached, and the oxygen consumption was then determined for 3 consecutive periods of 20 minutes each.

Oxygen consumption was determined for both the Sebago and the Pontiac varieties. The Sebagos were selected and irradiated separately from those used for $CO_2$ production.

## RESULTS

Figure 2 gives the results for whole tubers. With the exception of the tubers that received 5 kilorep, there was a considerable increase in respiration two days after irradiation. This was followed by a decrease after two or four weeks, and seven weeks after the irradiation the rate was low for all dosages. This low point was followed by an increase, which was dependent upon the dosage applied; the tubers receiving a dosage of 5 kilorep increased the least and those receiving the 200 kilorep, the most. The latter continued to show an even higher rate at the next analyses (13 weeks). By the thirteenth week the $CO_2$ produced by those tubers receiving dosages of 5, 15, and 25 kilorep was less than that of the controls and all except those receiving the 200 kilorep were respiring less than at the preceding analysis and then continued to respire less. In general, the observation was made that after the first rise in respiration the rate of respiration coincided with the dosage given. Those given the

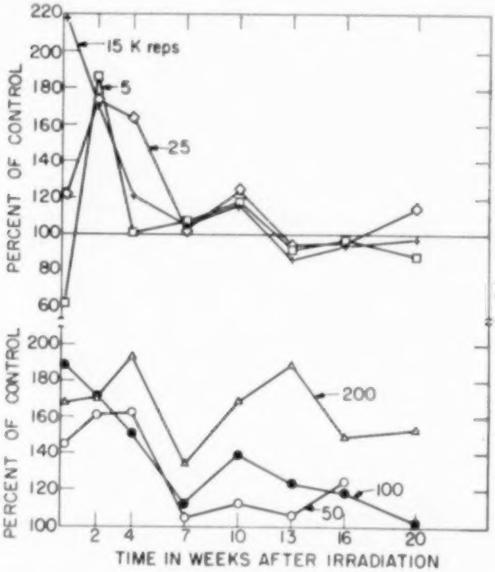


FIGURE 2.—Carbon dioxide production by whole tubers (Sebago), presented as per cent of the control tubers. Irradiation dosages given in kilorep.

lowest dosage respired the least and those having received the highest dosage used (200 kilorep) respired the most. There may be slight individual variations, but in general this is true.

A few days after the last $CO_2$ determination was made the potatoes that had been used for the duration of the experiment were examined externally and internally. Both control lots had a few small sprouts, never more than 5 mms. long, and they were somewhat wilted, but the flesh was white, with no blemishes. None of the irradiated tubers had any sprouts. The 5-, 15-, and 25-kilorep dosages caused internal browning in one tuber in each lot; otherwise they were as good as the controls. Fifty-kilorep irradiation caused more browning and 100 and 200 kilorep caused still more browning.

The oxygen consumption is given in figure 3 for the Sebago, and in figure 4 for the Pontiac. The day after irradiation there was an increase in oxygen consumption compared with that in the controls, but by the end of the week a decrease had developed except in those that had received the 200-kilorep irradiation. Those receiving the two lowest dosages were actually using less oxygen than the untreated samples. The assay made during the third week indicated a second peak, but from then on there was a decrease in consumption by the tubers having received the lower irradiation dosages, and the rate varied only a little when compared with that of the control, though generally it was a little lower. The tubers having received the higher dosage treatment continued to respire at a rate considerably higher than their control.

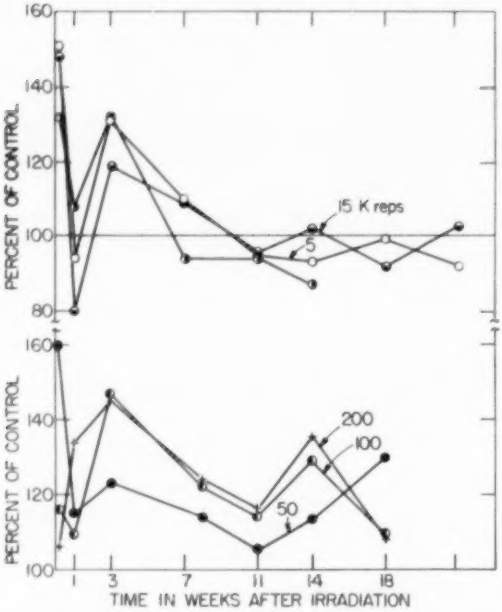


FIGURE 3.—Oxygen consumption by potato slices (Sebago) presented as per cent of the control tubers. Irradiation dosages given in kilorep.

Three weeks after irradiation, controls began to sprout, but only non-sprouting eyes were used. On the fourteenth week tubers having received 25 kilorep were wilted and showed pits caused by fungus infection. However, there were areas not infected, and these were used. The 50-kilorep treatment was causing considerable wilting. All others used were in good condition. By the eighteenth week all treated tubers showed considerable wilting. The 50-kilorep-treated tubers were the poorest and they showed black areas in the flesh, but these areas were not used. Twenty-two weeks after irradiation the 5- and 15-kilorep-treated tubers were essentially like the unirradiated controls, except that they had no sprouts. All were a little wilted.

The variety Pontiac was studied for only 6 weeks. The results are given in figure 4. The oxygen consumption on the second day after irradiation shows no relation to the dosage applied, but by the fourth week there was a positive relationship. By the sixth week there was a leveling off, but the tubers having received the 100- and 200-kilorep dosages were still consuming more oxygen than any of the others. As was to be expected there was no sprouting of any of these tubers, and all were in excellent condition.

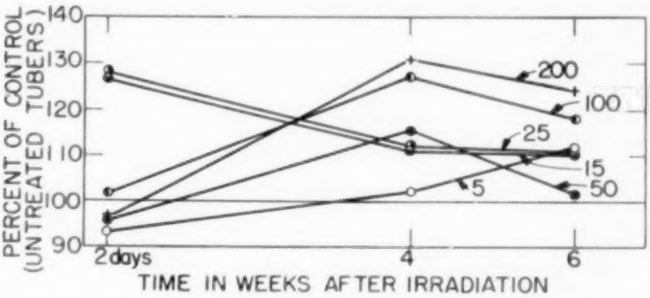


FIGURE 4.—Oxygen consumption by potato slices (Pontiac), presented as per cent of the control tubers. Irradiation dosages given in kilorep.

## Discussion and Conclusion

It has been demonstrated that both $CO_2$ production, with whole potatoes, and oxygen consumption, with slices, increase within a few hours after irradiation. The oxygen consumption decreased during the first week following the initial rise and then increased again, whereas the $CO_2$ production remained high for several weeks. The remarkable observation made during this study is that after several weeks of a high rate of respiration there was a drop of both $CO_2$ production and oxygen consumption by those tubers that had received dosages of 5, 15, and 25 kilorep. From the seventh week on these tubers respired at approximately the same rate as the controls. On the other hand, the tubers that had received dosages of 50, 100, and 200 kilorep respired throughout the experiment, at a rate higher than the controls.

The early rise may be associated with a greater utilization of energy, which could increase the respiration. The drop in oxygen consumption associated with a high $CO_2$ production may be due to a temporary aerobic fermentation, which has been frequently mentioned in the literature (1). The continued high rate could be associated with a rise in the sugar content, which lasts for several weeks (2). When this surplus sugar is used up, those tubers that received the lower dosages could be thought of as going back to their normal rate; no permanent physiological changes had been induced. Those tubers that had received dosages of 50, 100, and 200 kilorep continued to respire at a rate greater than that of the controls. This could be associated with injury as a result of the irradiation. There could be a shift in the path of respiration, whereby phosphorylation might be avoided. Millerd, Bonner, and Biale (3) have suggested that the increased respiration in ripening avocado fruits is caused by uncoupling of the phosphorylation in respiration.

From this study one can conclude that gamma irradiation of potatoes with dosages of 5-15 kilorep are most likely to prove satisfactory. These dosages inhibit sprouting over a storage period of at least 22 weeks, produce little or no alteration in the physical appearance of the tubers and after an early spurt in respiration settle down to a rate very nearly

that of the non-irradiated tubers. Higher dosages caused disturbances as browning, blackening, fungous infection, and an increase in respiration, which continued throughout the investigation.

### Literature Cited


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## NEWS AND REVIEWS

### SCOTTISH HOUSEWIVES KNOW THEIR TATTIES

E. C. Reid[1]

Housewives in Dundee, Scotland, may not know any more about settling the Suez situation than the top brass in the United Nations, but bless them, they do know a thing or two when it comes to detecting cooking quality in potatoes. According to a recent news report from Scotland, they also have sufficient faith in their judgment to back it up with a £5 wager.

Apparently (so the story goes) some of the consumers representing the Scottish Housewives' Association in Dundee, first sought this knowledge by writing letters to the papers about the tatties they were buying in the shops. They complained that the potatoes lacked quality, and claimed that perhaps the farmers were using too heavy an application of artificial fertilizer instead of the good old barnyard variety.

The farmers of course had their ideas on this question, too, some even having the temerity to suggest that the good ladies were just imagining things. However, to decide the question once and for all, one farmer sent three sacks of potatoes marked only A, B, and C to the housewives, challenging them to find out by cooking tests whether they were grown with artificial or natural manure. And moreover, the intrepid farmer let it be known that he would send a £5 cheque (about $12.50) to any charity that the ladies cared to name—if they won!

With money in sight, the Scottish Housewives' Association gleefully accepted the challenge—and the "Battle of the Tatties" was on. No one knew exactly what the sacks contained, no one at least except a lady reporter from one of the Dundee daily papers who was to act as a referee. They gave her a sealed envelope containing a key to the origin of the potato samples.

### Ladies Prove Their Point

As might be expected, excitement ran high when the ladies gathered around the steaming pots to taste the tatties. Not only their reputations as cooks were at stake, but they, too, had wagered five pounds sterling on the outcome.

But they need not have worried. The Scottish housewives apparently knew what they were talking about, and at least one potato grower was to discover that it does not pay to challenge a woman's judgment, at least, where potatoes are concerned.

After duly sampling the three lots of boiled potatoes, a vote was taken by the tatties tasters and it was soon found that the majority had unerringly picked the sample with the best flavor, color, and the most mealy texture—the sample that had received no artificial fertilizer.

"I think that the Scottish Housewives' Association have proved that they can recognize potatoes that have been produced with heavy applications of artificial fertilizers", one of the ladies was quoted as saying at the end of the test.

And now to end the story (as the radio commentators say), every one was happy at the outcome over in Dundee. The ladies, God bless them, had proved their point. The farmer concerned learned something and the "Auld Folkies" in Dundee's Eventide Home rejoiced greatly as the check provided them with many an extra cup of tea.

[1]Edmonton, Alta.

## BETTER TRUCK TRANSPORTATION OF PERISHABLE FOODS

Information on how to protect motor truck shipments of perishable farm products from deterioration in transit is contained in a handbook just released by the U. S. Department of Agriculture.

Requirements for protection against heat and cold are shown for a large number of commodities, including fresh fruits and vegetables, fresh meat and meat products, dairy and poultry products, and frozen foods. Methods of loading these commodities in trucks and truck-trailers to obtain the best results are also suggested, and there are more than 70 illustrations depicting loading techniques for different commodities in various types of containers.

Agricultural Marketing Service researchers compiled the data—much of which was previously available but widely scattered and difficult to find—into this easy-to-read handbook.

Supplements to the handbook are planned as additional information becomes available.

A single free copy of Agriculture Handbook No. 105, "Protection of Perishable Foods During Transportation by Truck", may be obtained from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

The Freezing Preservation of Foods. Third Edition. by Donald K. Tressler, and Clifford F. Evers. Avi Publishing Co., Inc., Westport, Conn. 1957. In two volumes. Volume I — Freezing of Fresh Foods. 1240 pages, 282 illustrations, 151 tables and 21 pages of front material. Price: $18.00 postpaid, domestic; $19.00 postpaid, foreign.

## REVIEW

This volume on Freezing of Fresh Foods along with its companion volume (II), Freezing of Precooked and Prepared Foods, ready in June, 1957, provide a complete compilation of information pertaining to the freezing preservation of foods. The authors have the assistance of one hundred and thirty scientists collaborating in the preparation of the two volumes. Emphasis is on the commercial freezing of foods but home care of frozen foods and home freezing are not neglected.

Volume 1, emphasizing the freezing of fresh foods, covers every phase of the industry: the economics and costs involved, the scientific principles pertaining to refrigeration and freezing, packaging information, warehousing and retailing instructions, and detailed procedures for freezing every type of fresh food.

The newer concepts of freezing are discussed in detail: dehydrofreezing, freeze-drying, and the freezing of concentrated fruit juices.

The microbiology of frozen foods, plant sanitation, quality control, and food standards are presented as important chapters.

A comprehensive reference book for the *industrial* commercial freezing of fresh foods.

WALTER A. MACLINN, *Chairman*
*Department of Food Technology,*
*Rutgers University.*

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## AMERICAN POTATO YEARBOOK

The 1957 edition of the AMERICAN POTATO YEARBOOK has just come off the press. The current volume contains 80 pages packed with vital information to the potato grower, shipper, jobber, research specialist and all others connected with potatoes in any way.

A special feature is the illustrated and informative article "The Story of Potato City." Also of significant interest are two pages of complete figures on potato acreage, yield, production, farm disposition and utilization in the U. S. from 1919 to 1955. There is in addition a current list of recent references to potato culture in the U.S. and Canada, complete information on United States Standards for Potatoes and details on leading potato producing areas.

The new volume again contains a wealth of statistical information. There are tabulations of both seed and table stock production as well as statistics on Canadian and world production. In addition, the current issue contains a list of books and periodicals of special interest to the potato industry.

The YEARBOOK is published by and may be secured from the AMERICAN POTATO YEARBOOK, 8 Elm Street, Westfield, New Jersey. An individual copy sells for $2.00. A complete volume, 1950-1957, is available at $9.00.

The YEARBOOK has no connection with the Potato Association of America.

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